THE FEASIBILITY OF A COMPUTER-BASED INSTRUCTIONAL SYSTEM IN THE DES MOINES AREA

A Field Report

Presented to

The School of Graduate Studies

Drake University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

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by

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August 1971

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TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER I

INTRODUCTION

About ten years ago computer-assisted instruction existed in a conceptual sense only. This conceptual idea has become a reality and today educational uses of the computer have skyrocketed in research laboratories and schools all over the country.[1] Many educators recognize the challenging and uplifting effects of computerized instruction on educational standards. Max Rafferty, former State Superintendent of Public Instruction in California, made the following observation:

> The impact of computers and computer sciences upon our society is growing daily; education is no exception to this phenomenon. No one can foresee the ultimate contribution of these amazing instruments, but most knowledgeable scientists and scholars are convinced it will be immense; here too education is not exempt. The educator who sees the computer only as an oversized calculator has missed the essence of the computer revolution. In our time we can expect the structure, form, and process of education to become as different from today's education as night is from day. The computer sciences are playing an increasing role in these dramatic and far reaching changes.[2]

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[1] Richard C. Atkinson (ed.), "Computer-assisted Instruction," Computer-assisted Instruction: A Book of Readings (New York: Academic Press, Inc., 1969), p. 2.

[2] Alvin Grossman and Robert L. Howe, Data Processing for Educators (Chicago: Educational Methods, Inc., 1965), p. vii.

I. THE PROBLEM

Computer-assisted instruction (CAI) is the use of a computer to "supplement or enrich the teacher's instruction by taking over the more routine daily tasks, presenting special materials, or giving the daily lesson itself."[1] This type of instruction requires a computer system or hardware, program or software, the student, the teacher and/or programmer.[2]

Statement of the problem. In the Des Moines area there are two main sources of computer facilities directly connected with education. Drake University houses a Honeywell 200 and the Polk County Project Access utilizes an IBM 360/30. Neither of these centers has implemented computer-assisted instruction into their systems. It is at this point that a question, which is the major concern of this study, arises: Is it academically, financially and technologically feasible to implement a computer-based elementary mathematics instructional system into the existing computer facilities in the Des Moines area?

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[1]Patrick Suppes, Max Jerman and Guy Green, "Arithmetic Drills and Review on a Computer-based Teletype," Arithmetic Teacher, XIII (April, 1966), 303-304.

[2]Albert E. Hickey and J. M. Newton (eds.), Computer-assisted Instruction: A Survey of the Literature (Newburyport, Massachusetts: Entelek, Inc., 1968), p. 45.

It is the purpose of this study to explore the present applications of CAI in elementary mathematics and to identify necessary additions and expenses required to implement CAI on a limited basis in the Des Moines area.

Importance of the study. A trend toward CAI usage seems to be increasing. Presently, there are thirty major CAI centers, ten school systems have full-scale projects, and approximately 500 schools have acquired a limited CAI capacity.[1] Publishers such as Random House, Harper and Row, Science Research Associates, and Harcourt Brace and Javonovich have been developing instructional programs either alone or in collaboration with one of the computer manufacturers. The long range commitment of these publishers and hardware companies gives an indication of present reality and future development.[2]

Because of the increasing usage of CAI, the importance of this field report comes to light in that it presents the research and background information necessary for utilizing and/or expanding the Des Moines area computer resources for a CAI system on a limited basis.

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[1] Ibid., pp. 26-44.

[2] Atkinson, op. cit., p. 5; Statement by J. P. Martin Clinton, telephone interview, June 23, 1971; Statement by John Klinger, telephone interview, June 24, 1971; Statement by Gerard Kotlier, telephone interview, June 23, 1971.

II. QUESTIONS TO BE ANSWERED

The four major areas of investigation of this study are: (1) elementary mathematics CAI curriculum materials; (2) legal aspects of the computer utility and programs; (3) CAI costs, including hardware, software, program development, and personnel; and (4) computer equipment and technical aspects. These areas gave rise to the following questions:

1. What elementary math materials are currently available which could be purchased and adapted for use in a CAI system in Des Moines?
2. What materials and programs would need to be produced locally to implement a program?
3. What are the legal aspects of the computer utility and programs which would affect such a system in the Des Moines area?
4. What would be the cost of establishing an elementary math CAI in Des Moines?
5. What aspects of the current Des Moines computer facilities are adequate for implementing CAI?
6. What additional equipment and/or technical aspects would be necessary?

III. PROCEDURE

The methodology employed to answer the questions in the preceding section include three major techniques to collect preliminary data: (1) review of the literature; (2) interviews; and (3) letters of inquiry.

Review of the literature. A systematic review of current machine capacities, available materials, and necessary structures was made to provide a basis for determining the specific answers to the questions asked.

Interviews. Interviews were arranged with computer center personnel from Drake University and the Polk County Project Access, and with representatives from the major data processing firms in the Des Moines area. Information was also secured through long-distance telephone interviews with directors of CAI projects and computer manufacturer personnel.

Letters of inquiry. Letters requesting information on the nature and extent of their CAI involvement were sent to the major centers, projects, school systems, computer manufacturers, education and publishing companies. The list was compiled from professional journals and advertisements which gave indication of their involvement in elementary mathematics CAI.

CHAPTER II

REVIEW OF LITERATURE

I. INTRODUCTION

Although the "'teaching machine' movement is not a new development since the first teaching machine was patented in 1866,"[1] research has come a long way in CAI in the last five years. It was not until 1965 that extensive research began in elementary mathematics in centers such as New York City Schools, The Pennsylvania State University, University of Illinois, Waterford Township in Pontiac, Michigan, and Stanford University and all its networks. The major full scale nation-wide efforts in elementary math have been carried out under the direct supervision of Dr. Patrick Suppes, director of the Institute for Mathematical Studies in the Social Sciences, and his research associates at Stanford University.[2]

Chapter II will deal with a review of the CAI research literature from a philosophical and educational

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[1]William A. Deterline, An Introduction to Programmed Learning (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 9.

[2]Richard C. Atkinson, "Computer-assisted Instruction," pp. 2-6; Ronald Arnold, "INDICOM: Final Report" (Waterford Township School District, Pontiac, Michigan), CAI Report, November 30, 1970.

standpoint. This will provide a basis for a discussion of technical considerations relating to curriculum, equipment, and cost for CAI in the Des Moines area which will be presented in Chapter III. The five major areas presented in Chapter II include: (1) CAI research evaluation; (2) curriculum materials; (3) legal aspects; (4) costs; and (5) equipment.

II. CAI RESEARCH

Despite the trend for CAI and researchers' quest to optimize the learning process, it appears that not all results of CAI measure up to the capabilities. Furthermore, research evaluation in terms of effectiveness, if stated prematurely or in the wrong terms, is a very severe problem. Several years ago researchers reported tremendous effectiveness with children who learned more in the same amount of time than others not using the computer, and they indicated that there was definite improvement over a period of time.[1]

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[1]C. Victor Bunderson and J. L. Dunham, "The University of Texas Computer-assisted Instruction Laboratory 1967-1968," (College of Education at the University of Texas, Austin), CAI Report, 1968, p. 51; Robert Bundy, "Computer-assisted Instruction--Where Are We?" Phi Delta Kappan, 48:424-429, April, 1968; Donald Bitzer, "The Uses of PLATO: A Computer Controlled Teaching System," Audio-visual Instruction, 11:19, January, 1966; John E. Coulson (ed.), Programmed Learning and Computer-based Instruction (New York: John Wiley and Sons, Inc., 1962), pp. 189, 238, 239; Patrick Suppes, "The Uses of Computers in Education," Scientific American, 215:207-220,

At the present time, researchers seem to be taking a more cautious approach in reporting their findings in terms of capabilities rather than conclusions.[1] Dr. Anthony G. Oettinger of Harvard University took a pessimistic view on all computer-assisted instruction claims. Oettinger insisted that future prospects of CAI were being based on false assumptions about present accomplishments because the claims of researchers bear no relationship to the traditionally-administered schools as they exist now, and he aggressively attacked the Office of Education, the education companies, the system analysts and the computer industry.[2] Because of Dr. Oettinger's reasons and because at the present time there is no sound theory for development of instructional materials based on different styles of learning and levels of achievement, it is quite difficult to measure CAI effectiveness. Therefore researchers will hesitate to give

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September, 1966; "Accelerated Program in Elementary School Mathematics--The Fourth Year," (CAI Laboratory, Institute for Mathematical Studies in the Social Sciences in Stanford University, Stanford), Technical Report No. 148, August 7, 1969, p. 26; "Computer-assisted Instruction," Science, 166:343-358, October, 1969.

[1]Bundy, op. cit., p. 425; Suppes, "The Uses of Computers in Education," pp. 207-220.

[2]Robert W. Locke and David Engler, "Run, Strawman, Run,: A Critique of Run, Computer, Run," Educational Technology, X, 3 (March, 1970), 47-50; Anthony G. Oettinger and Sema Marks, Run Computer, Run: The Mythology of Educational Innovation (Cambridge, Massachusetts: Harvard University Press, 1969).

conclusive results until there has been more long range experimentation.[1]

III. CURRICULUM MATERIALS

The capabilities exist for the production of the very best of individualized curriculum materials. However, in addition to premature research evaluation, another major reason why CAI lacks credibility as a feasible educational tool is the shortage of effective and efficient curriculum materials.[2] It is estimated that the time required for qualified personnel to design, write, de-bug, and validate one hour of CAI is anywhere from 75 to 1,000 man hours.[3] Random House, Computer Curriculum Corporation, and Science Research Associates have prepackaged elementary math CAI materials and have placed them on the market starting at $100 per terminal. However, these programs may be subject to continuous revision, additions and deletions to guard against unsatisfactory lessons.[4]

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[1]Atkinson, op. cit., p. 10. [2]Hickey, op. cit., p. 7.

[3]Bundy, op. cit., p. 426; Hickey, op. cit., pp. 3, 93.

[4]Arnold, op. cit., pp. 1-5; Richard A. Giesen (pres.), Science Research Associated, 1971 Catalog (Chicago: Science Research Associates, Inc., 1971), pp. 84-85; Robert M. Gordon (ed.), Introduction to HP Mathematic Drill and Practice Programs (Cupertino, California: Hewlett Packard Company, 1971), pp. 1-15; Statement by J. P. Martin Clinton, telephone interview, June 23, 1971; Statement by John Klinger, telephone interview, June 24, 1971.

Without proper software (curriculum programs), the hardware (computer) might be classified as what Dr. Launor F. Carter, senior vice-president of System Development Corporation, terms a "GIGO System--garbage in and garbage out."[1] Based on the possibility of a "GIGO-system," critics of technology fear that CAI may result in impersonalized teaching, standardization of education, and educators becoming slaves of machines. Dr. Patrick Suppes and Dr. Bruce Hicks of the University of Illinois agreed that all these points are a possibility in CAI, but continue to feel optimistic:

> If our applications of computer-assisted instruction embody creativity, patience, tolerance, and objectivity rather than passivity, impatience, bigotry and irrationality, then the computer will serve education rather than kill it.[2]

Although shortage of CAI curriculum materials is a severe problem, researchers such as Dr. Suppes will continue to develop, improve and revise programs.

IV. LEGAL ASPECTS

Besides premature evaluation and shortage of curriculum materials, another area that could possibly present

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[1]Charles E. Silberman, "Technology Is Knocking at the Schoolhouse Door," Fortune, LXXIV (August, 1966), 123.

[2]Bruce L. Hicks, "Will the Computer Kill Education?" Educational Forum, XXXIV, 3 (March, 1970), 312: Patrick Suppes, "Computer Technology and the Future of Education," Phi Delta Kappan, 48:420-423, April, 1968.

a problem, or discourage further CAI research or future classroom usage, are the legal aspects of computer services and rights of ownership of software or CAI programs.

Computer services. Time-sharing, or a remote access immediate response in which a number of users communicate simultaneously,[1] has been referred to as a "computer utility" and because of the word "utility," it implies federal legislation.[2] The Federal Communications Commission is undergoing investigations and inquiry into the relationship between computers and communication. Presently, time-sharing firms are not federally regulated, nor are they obligated to serve all subscribers, nor are they bound by standards of adequate service or reasonable prices.[3]

Proprietary software. Three bills currently in Congress, the Copyright Revision Bill, the Administration Bill and a federal law of Unfair Competition, deal with the legal aspects of proprietary software. Copyrighting computer programs is a highly complicated matter because there is a big question as to who owns the program, which might be the

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[1]Richard T. Bueschel and others, Commercial Time-sharing Services and Utilities (New York: American Management Association, Inc., 1969), p. 10.

[2]Ibid., p. 41. [3]Ibid., p. 50.

person who developed the program, the organization with which the individual programmer is associated and/or the program user who finds it necessary to do some editing. Patents for computer programs, which would come under the Administration Bill, are even harder to provide for since computer programs have not been adequately defined nor have ownership rights been established. The U. S. Law of Unfair Competition will provide protection for individuals' and/or companies' software against misuse and dishonest business practices.[1]

Historically, federal legislation and investigations have benefited education[2] so that Federal Communications Commission rulings and passage of the above bills would probably encourage rather than stifle CAI by establishing standards of adequate service, reasonable prices, prevention

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[1]Robert B. Bigelow, "Legal Aspects of Proprietary Software," Datamation, 11:32-39, October, 1968; "Some Legal Aspects of Commercial Remote Access Computer Services," Datamation, 15:48-52, August, 1969; Hickey, op. cit., p. 96.

[2]Keith Beaven, "United States: Fraud Charges to Be Investigated," Times Educational Supplement, 2846:12, December, 1969; George A. Kizir, "Federal Aid to Education: 1945-1963," A History Education Quarterly, 10:84-102, Spring, 1970; Sidney W. Tiedt, The Role of The Federal Government in Education (New York: Oxford University Press, 1966); Herman I. Orentlicker, "Education in Legislation and the Courts: A Summary of Recent Developments," AAUP Bulletin, 51:429-436, December, 1965.

of monopolistic control of software and dishonest business practices.[1]

V. COST

Besides premature evaluation of research, shortage of curriculum materials, and possible legal complications, cost continues to be a major problem in CAI. A true evaluation in terms of costs may be unrealistic because a computer system is much too complex to be able to identify specific costs of even a small portion of a project. Because of factors such as inefficient use of the computer and high start-up costs, it is possible that the cost of running a small project with one terminal may not be that much different from running a project with twelve terminals in a more sophisticated system. Another reason an evaluation in terms of cost may seem unrealistic at the present time is that there is a trend for more standardized equipment design and more efficient production methods which in turn continually reduce costs.[2]

At present, the per terminal hour costs are quite high even with the simplest systems available and they

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[1]Bigelow, "Legal Aspects of Proprietary Software," pp. 32-39; "Some Legal Aspects of Remote Access Computer Services," pp. 48-52; Hickey, op. cit., p. 96.

[2]Atkinson, op. cit., pp. 9-10; E. Wainright Martin, Jr., Electronic Data Processing: An Introduction (Homewood, Illinois: Richard E. Irwin, Inc., 1965), p. 493.

increase rapidly with addition of more sophisticated components. Hardware costs range from $180,000 for a small computer to 4.5 million dollars for a respectable one with extended memory. In addition, software, including course development and programming, would range from $9,000 to $1.5 million.[1] Other minor costs, such as telephone line rental for remote units, are not included in these figures.

Given present machine costs, many school districts could not afford a computer system. However, Richard T. Bueschell, president of Time-Share Corporation, predicted that as a result of time-sharing the computer power available in public schools will continue to broaden because of massive reduction in storage costs and less expensive equipment.[2] In a time-shared computer system it has been estimated that the cost of per student contact hour amortized over a five-year period would be approximately thirty-four cents as compared

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[1]Donald Bitzer and D. Skaperdas, "The Design of an Economically Viable Large Scale Computer Based Education System," Research Laboratory in the University of Illinois, Urbana), CERL Report x-5, February, 1969, p. 18: Felix F. Kopstein and R. J. Seidel, "Computer-assisted Instruction vs. Traditionally Administered Instruction: Economics," Audio-Visual Communication Review, 16:170, Summer, 1968: Oettinger and Marks, op. cit., pp. 190-199.

[2]Richard T. Bueschel, "Time-sharing: A Pragmatic Approach in the School," Educational Technology, X, 3 (March, 1970), 47-50.

to thirty-six cents of traditionally-administered instruction.[1]

With realistic evaluations in terms of cost not now available and with massive costs still prevalent, economic feasibility of CAI will not occur until sometime in the future.

VI. THE EQUIPMENT

Although the computer has some technical shortcomings, it has phenomenal capacities to be more logical, knowledgeable, patient, humane, educationally effective and faster than the traditional classroom teacher.[2] The computer, at tremendous speeds, is able to make logical decisions, record and manipulate massive amounts of data concerning individual differences, sequence of learning, depth of material, instructional strategy and rate of progress.[3] The computer not only reduces the amount of certain tedious work, but also can integrate and control a wide variety of audio-visual aids in the learning process.

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[1]Donald Bitzer, "The Design of an Economically Viable Large Scale Computer-based Education System," p. 18: Felix F. Kopstein, "Computer-assisted Instruction vs. Traditionally Administered Instruction: Economics," p. 170; Oettinger, op. cit., pp. 190-199.

[2]Hickey, op. cit., p. 312; Hicks, op. cit., p. 312.

[3]Patrick Suppes, "The Uses of Computers in Education," pp. 207-220; "Computer Technology and the Future of Education," pp. 420-423.

The complexity of the hardware itself gives rise to technical problems which interfere with the learning process. For example, the storage of random or direct access audio tape units in digital form is not only bulky and costly, but also difficult to program and retrieve without creating transmission problems at one time or another.[1] Other technical problems that hinder CAI include breakdowns and lack of standardized equipment which make for extra programming.

In summary, educators have had technical problems resulting in snags in their CAI research, but their feeling is that the computer has phenomenal capacities and perhaps the single most important aspect is "that the kind of individual instruction once possible for a few members of the aristocracy can be made available to all students at all levels of abilities."[2]

VII. SUMMARY AND CONCLUSION

Computer-assisted instruction research in the area of elementary mathematics has become quite extensive in the last five years. The computer has been found to have tremendous

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[1]Atkinson, op. cit., p. 9; Bundy, op. cit., p. 425.

[2]Suppes, "Computer Technology and the Future of Education," p. 420.

capabilities to optimize the learning process. However, problems in five areas have been uncovered: (1) premature inadequate evaluation of research; (2) shortage of curriculum materials; (3) legal implications; (4) cost; and (5) technical problems. These problems and capabilities can best be summarized by Dr. Patrick Suppes' observation that:

> . . . it is of the greatest importance to emphasize that the existence of the technology and the recognition of its possibilities are not in themselves sufficient to guarantee that it will be used wisely or that it will be used with anything like maximum efficiency. From the standpoint of educational theory and practice, the deep and complicated problems begin only when it is recognized that technology is ready for application and that we need to understand how it should be used.[1]

Because "we need to understand how it should be used," one of the most critical and important applications of CAI is on an experimentation basis to learn about learning and perhaps to develop a sound theory of learning.[2]

Given the facts: that we need a learning theory; that CAI experimentation in elementary mathematics was virtually non-existent prior to 1965; that computer companies are committing themselves financially in the area; that the federal government has historically passed legislation favoring

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[1]Arnold, op. cit., p. 66.

[2]Bundy, op. cit., p. 428.

education and will probably continue to do so; that there is a trend in reduction of costs due to improvements in programs and equipment; it is reasonable to expect that there will and should be a continuance of CAI research.

CHAPTER III

CAI IN THE DES MOINES AREA

I. INTRODUCTION

An educational evaluation of CAI is of prime importance in implementation of a project. This was presented in Chapter II and will therefore not be mentioned in Chapter III. A thorough search through the U. S. Code Annotated and the United States of America Congressional Record of Proceedings and Debates since 1967 revealed that none of the proposed bills dealing with the legal aspects of computer usage have become laws nor have they passed out of committee conferences or hearings.[1] Because of this, legal implications offer no special problems at the present time and will not be discussed in this chapter.

However, considerations relating to curriculum, equipment, and cost using existing computer facilities must be discussed in detail. Although there are several computer manufacturers and educational companies involved in CAI, the discussion will be limited to only those dealing with elementary mathematics applications of CAI. Chapter III will cover four main areas: (1) necessary considerations for CAI in the

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[1]U.S. Code Annotated, I-L, 1968; U.S. Congressional Record, 90th Cong., 1st Sess. (1967), CXIII, No. 7, 8604 through 92nd Cong., 1st Sess. (1971), CXVII, S9738 and H5735.

Des Moines area; (2) prepackaged materials available; (3) adaptation of the Des Moines area equipment to the prepackaged materials; and (4) purchasing new equipment for CAI. This section will deal with costs of the materials and the equipment only, unless otherwise indicated. Actual costs would be slightly higher after CAI personnel salaries, installation, servicing, and other miscellaneous fees are added to the hardware and software prices.

II. REQUIREMENTS FOR CAI

Before any planning for a CAI system is begun, decisions must be made regarding the materials which will be used and the size of the project, or the terminals to be utilized.[1]

Commercially prepared materials. Keeping in mind that the CAI project would be a small one, it is very unlikely that the materials would be developed locally. It has been previously pointed out that the designing, writing, de-bugging, and validating of CAI materials requires very qualified personnel with much experience and technical skill. It also involves a considerable amount of time and huge costs. Dr. Patrick Suppes, at Stanford University, began research and development in January, 1963, and it was not until the spring

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[1]Statement by Albert Anderson, personal interview, October 19, 1970.

of 1964 that the campus laboratory went into operation.[1] In the full-scale CAI project at Waterford Township School District forty teachers were trained in a period of two years as CAI authors. Initially, commercially prepared materials were utilized at this project and still, to some extent, their use is continued.[2] Both of these projects have been able to carry out research through large grants from the Federal government.[3]

Neither of the Des Moines area computer centers are undergoing any kind of research and development of CAI materials nor have they investigated the possibilities of implementing CAI. Since prepackaged materials have been used satisfactorily, it is reasonable to establish that prepackaged materials should be used when beginning a project in Des Moines.

Size of project. The second requirement in establishing CAI in the Des Moines area is setting up the maximum number of

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[1]"Brief History of Computer-assisted Instruction" (Stanford: Institute for Mathematical Studies in the Social Sciences, Stanford University, October, 1968). (Mimeographed.)

[2]Robert W. Scrivens, "INDICOM: Evaluation Monograph" (Waterford Township School District, Pontiac, Michigan), Report No. 1, February, 1970.

[3]Arnold, op. cit., p. iii; Hickey, op. cit., pp. 6-7; William A. Rybensky and others, "Computer-assisted Instruction in the Ravenswood City School District" (East Palo Alto, California: Stanford CAI Laboratory, March, 1970), p. 5. (Mimeographed.); "Brief History of Computer-assisted Instruction," loc. cit.

terminals that will be used. Stanford University has used as few as one terminal and as many as thirty-six in a single school district.[1] As has been pointed out before, cost is one of the great hindrances to CAI and it will be this single factor that will limit the number of terminals. The terminals themselves may be available for forty dollars a month per terminal, including servicing.[2] For every additional terminal that is used, increases in power, capacities, and cost are necessary. Small computers which can handle eight student terminals have been placed on the market starting at $10,400.[3] Because of the existence of these small computers, a definition of a reasonably small CAI project will be one that has a maximum of eight terminals.

In summary, there are two basic requirements regarding materials and size of project that are necessary for CAI in Des Moines. Development of materials requires much educational experience, technical skill, time, and money. Prepackaged materials have been used satisfactorily. Considering that the

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[1]Max Jerman (Co-ordin.), "CAI Newsletter" (Stanford: Institute for Mathematical Studies in the Social Sciences, Stanford University, November, 1968). (Mimeographed.)

[2]"Curriculum Package Pricing Structure" (Palo Alto, California: Computer Curriculum Corporation, April, 1971), pp. 1-17.

[3]Ibid.

Des Moines centers are not involved in CAI, prepackaged materials should be used. Because of the existence of small computers that can handle eight terminals, a definition of a reasonably small CAI project will be one that has a maximum of eight terminals.

III. COMMERCIALLY PREPARED MATERIALS

Once the decision has been made to use prepackaged materials and the size of the project has been determined, the next question is: what mathematics materials are available? At the present time there is one educational company (Science Research Associates), one publishing company (Random House), and two computer companies (Hewlett-Packard and Computer Curriculum Corporation), that have developed elementary drill and practice CAI mathematics programs.

Science Research Associates. A subsidiary of IBM, Science Research Associates, has a CAI program that may be leased at an annual charge of nine thousand dollars. It may be used on IBM equipment or on computers using the COURSEWRITER III, Version 2 language.[1]

Random House. L. W. Singer (now Random House) has a math package on the market which was designed especially for RCA equipment, the Spectra 70. The software may be leased annually

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[1]Giesen, loc. cit.

for one hundred dollars per terminal. The math package is available for computers utilizing the LISA language which is a more comprehensive language than COURSEWRITER.[1]

Hewlett-Packard. The cost of leasing the HP math package is a total sum of one dollar to educational institutions. However, either the HP2000A or the HP 2000B, the hardware which is the equipment the program was designed for, must be purchased or leased from Hewlett-Packard. The list price for leasing the system may be for as little as $115,000 and up to $200,000.[2]

Computer Curriculum Corporation. The fees for leasing the CCC software are ten dollars per terminal a month, with a requirement of a minimum of ten terminals. This program was designed for the CCC Instructional System. The system, including terminals, curriculum materials delivery, installation, and maintenance may be leased yearly for as little as $15,310. The math package is also available to Univac 418 users. By 1972 it will also be available for IBM and Digital Equipment Corporation computers.[3]

To summarize, there are four elementary drill and practice mathematics computer programs that may be leased

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[1]Klinger, loc. cit. [2]Kotlier, loc. cit.

[3]Clinton, loc. cit.; "Curriculum Package Pricing Structure," loc. cit.

and used on a limited number of computers. The Hewlett-Packard package is available only as a combined hardware and software system starting at $115,000. A second commercially developed package is available from Random House for computers utilizing the LISA language at one hundred dollars per terminal per year. Science Research Associates have a math package listed for nine thousand dollars a year and is available for computers using the COURSEWRITER III, Version 2 language. The fourth program is available as a combined Computer Curriculum Corporation hardware and software instructional system starting at $10,400. It is also available for Univac computers at ten dollars per terminal a month.

IV. THE DES MOINES EQUIPMENT

In adaptation of the Des Moines equipment to prepackaged CAI materials, the Hewlett-Packard and the Computer Curriculum Corporation systems will be ruled out because they are available as combined hardware and software systems. Only the SRA and the Random House materials will be considered. It is the purpose of this section to present a brief discussion of the major necessary additions, technical aspects and problems in the use of commercially developed materials, rather than a lengthy concentrated study.

The Drake University Computer Center utilizes a Honeywell 200 series with a storage capacity of 32k core and can

handle the languages, FORTRAN and COBOL. The center also has two disk drives, four tape drives, a printer, a card reader, and punch. The Polk County Project Access has an IBM 360/30 with 65,000 portions of core and can accommodate programs written in the COBOL, FORTRAN, BAL, and RPG languages. This center has three disk drives, two tape drives and three peripheral devices, a printer, a card reader, and punch. Both of these centers have storage capacities that are more than adequate for accommodation of CAI lessons.[1] However, certain problems arise.

Compiler. Probably the largest problem, as pointed out previously, is the lack of standardized equipment. Programs are designed for a particular computer and cannot be taken from one machine and placed in another without experiencing problems. The CAI programs from SRA and Random House are written in the COURSEWRITER and LISA languages, respectively. Neither of the computers in the Des Moines centers accept these languages. Sometimes a translator is necessary so that the machine can understand different languages. An automatic translator in the computer would take a language, such as COURSEWRITER or LISA (language 1) and output it as a language (language 2) that the machine will accept as is shown:[2]

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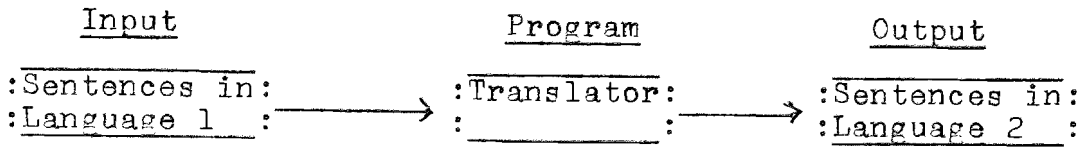
[1]Anderson, loc. cit.

[2]Dennis Keith Branstad, "A Computer Aided Instructional System for Teaching Formal Language" (unpublished Doctoral dissertation, Iowa State University, 1970), pp. 19-24.



There are compilers or translators for the COURSEWRITER language available for licensing, but even these may be inadequate for implementation of mathematics CAI.[1] Designing, development, de-bugging, and implementing a compatible compiler for the languages COURSEWRITER and LISA takes many months and maybe a few years, as do the CAI lessons. In this respect, development or licensing of a compiler is one reason why the commercially developed materials may not be reasonably adaptable to the Des Moines equipment.

Peripheral devices. The Des Moines centers would need additional components in addition to the extra programming. Input-output equipment which would be needed includes such units as student terminals, a control unit, a communications data set and cables, a paper tape reader, and a paper tape punch. A control unit acts as a supervisor for the terminal. Some teletype terminals have not only a printer but also a paper tape output used for student records and for this reason

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[1]IBM Price Code Manual (Chicago: International Business Machines Corporation, 1971).

a paper tape reader is necessary. The student terminals would not likely be located in the same building as the center so that communications units such as data sets and cables would need to be leased.[1]

Addition of all the extra components and programming in order that the computer may accept the CAI lessons and output them on student terminals make the entire system bulky and costly. Additions would be necessary because these centers were not initially set up for CAI, but rather for a main function of data processing. These additions, as discussed previously, are quite costly. Additional components for the Des Moines centers, including curriculum materials discussed in the previous section, may be leased annually for approximately $18,778 as is shown:[2]

	Monthly	Yearly
Eight terminals @ $112/terminal/month	$ 896	$10,752
Curriculum materials @ $10/terminal/month	80	960
Supplies	10	120
Compiler	150	1,800
Control Unit	200	2,400
Paper Reader	29	348
Paper Punch	39	468
Data Set	10	120
Cable	150	1,800
Total	$1,564	$18,778

[1]Hickey, op. cit., pp. 45-58.

[2]IBM Price Code Manual, loc. cit.

It must be emphasized that these prices are only approximate and are subject to change due to any number of factors. Educational discounts were not taken into account, and installation, delivery, and maintenance fees were not added. Addition of all the necessary programming and components to the existing equipment would have approximately the same costs as a small, more efficient time-sharing system with higher capacities for CAI and data processing or the leasing of a small computer which could handle CAI.[1]

To summarize, the basic data processing configuration of the Des Moines centers could possibly be adapted for commercially prepared CAI lessons with special addition of a compiler, programming, and equipment. Speaking in terms of computer efficiency, costs, and the time element, neither of the Des Moines centers are adequate for adaptation of commercially prepared CAI materials.

V. NEW EQUIPMENT

Because existing equipment examined in the above section cannot reasonably be adapted for a small project, it does not mean that a project on a limited basis is totally impossible.

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[1] "Curriculum Package Pricing Structure," loc. cit.; Hickey, loc. cit.; Gerard P. Weeg (ed.), "Some Alternatives for Providing Computer Facilities to Small Colleges," Proceedings of a Conference on Computers in the Undergraduate Curricula (Iowa City: The University of Iowa, June 15, 17, 18, 1970), pp. 11.13-11.18. Hereafter referred to as Conference on Computers.

Purchase of a small computer, such as the CCC Instructional System with prepackaged math programs, offers such a possibility. Unlike Hewlett-Packard, IBM, and RCA computers which offer remote access, time-sharing, large storage and data processing capacities besides CAI, the CCC hardware are strictly one-building computers and can be used for the CAI mathematics program only.

At the present time the CCC Instructional System is the only elementary mathematics CAI small scale system that has been placed on the market at comparatively low rates.[1] The equipment is available from Computer Curriculum Corporation. The offerings include computers in three different sizes and there is a decrease in system costs that parallels an increase in the number of terminals used. Terminals are not included in the package, but may be rented from CCC at forty dollars per terminal a month. Terminal rental and other fees, which include installation, supplies and monthly system rental, are based on a twelve-month year. The Instructional System, number of terminals, and costs, is shown:[2]

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[1]Arnold, loc. cit.; "Curriculum Package Pricing Structure," loc. cit.; Introduction to the PH Mathematics Drill and Practice Program, loc. cit.; Science Research Associates Catalog, 1971, loc. cit.

[2]"Curriculum Package Pricing Structure," loc. cit.

Instructional System	Number of Terminals	Basic Price	Terminal, Other Fees	Total First Year
CCC M8	8	$27,500	$4,910	$32,410
CCC M12	12	35,000	7,290	42,310
CCC M16	16	42,000	8,690	51,710

Total costs are highest the first year and decrease drastically in subsequent years in which the project is in operation. The eight terminals can accommodate approximately 250 students for a total cost of $135 per student the first year and for a total cost of $18 per student in subsequent years as is shown:[1]

		Costs for First Year		Costs for Second Year	
Instructional System	Number of Students	Total	Per Student	Total	Per Student
CCC M8	250	$32,410	$135	$4,560	$18
CCC M12	375	42,310	113	6,780	18
CCC M16	500	51,710	104	9,000	18

Doubling the number of students from 250 to 500 would reduce the unit costs by almost 23 per cent from $135 per student to $104 per student during the first year. However, the purpose of this field report is to establish the feasibility of a small project. A small project was defined as having eight terminals. Therefore the cost of running an eight-terminal drill and practice CAI system in Des Moines would be $32,410

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[1] Ibid.

for the first year and $4,560 for subsequent years. This would mean that the cost per student would be approximately $135 the first year and approximately $18 for subsequent years.

VI. SUMMARY

A thorough understanding of the philosophical and educational evaluation of CAI research is necessary in any feasibility study for implementing a project. In establishing CAI on a limited basis in the Des Moines area there are four areas of concern: (1) basic requirements for CAI; (2) commercially prepared materials available; (3) the capacity of the existing equipment; and (4) the possibility of purchasing new equipment.

The two basic requirements in establishing CAI include the usage of commercially developed curriculum materials and having a maximum of eight terminals. Prepackaged materials must be used because the Des Moines centers have not done any research and development of CAI lessons and to do so would require much experience, technical skill, time and money. An eight-terminal project was chosen because computers capable of handling that number of terminals can be leased or purchased at relatively low rates.

Prepackaged materials available for use in the Des Moines centers include programs from SPA and Random House. These are

subject to certain restrictions. The SRA program is available for computers utilizing the COURSEWRITER III, Version 2, language and the Random House math package is available only for those computers utilizing the LISA language.

The adaptation of either of these programs to the Des Moines Centers is possible, but many problems come into view. Besides the addition of expensive components, it would take much technical skill and time for designing and adding compatible computer assembly languages so that the equipment would be able to receive the CAI lessons. The efficiency of the computer would go down and the costs of implementing would be prohibitively expensive. These problems are so tremendous that the only possible conclusion is that the CAI packages are not technically or economically adaptable to the existing hardware.

However, the possibility of CAI in Des Moines is not entirely ruled out. The purchase of the CCC M8 Instructional System, a small computer with a prepackaged math program, may be a reasonable alternative. Servicing about 250 students for approximately $135 per student the first year, the CCC M8 is available at a total cost of about $32,410. In subsequent years, it is available at $4,560 or approximately $18 per student.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

I. CONCLUSIONS

The major concern of this field report was to determine feasibility of a small computer-based elementary mathematics instructional system in the Des Moines area. A systematic investigation of present mathematics applications was made in order to formulate conclusions concerning the requirements of a small project in Des Moines. The four major areas of investigation include: (1) CAI curriculum materials; (2) legal aspects of computer usage; (3) costs; and (4) equipment. Information was obtained through a review of the literature, letters of inquiry to research centers and companies involved in CAI, and through interviews with personnel from computer companies, CAI projects, and centers.

Present CAI applications. Utilizing the information gathered, general conclusions may be made concerning present elementary mathematics applications. Increasing usage of CAI in schools and research centers and the long-range financial commitment made by computer and educational companies support the idea that CAI is a definite educational trend. Based on current increasing CAI usage and long-range experimentation, it is safe to conclude that there will be an increase in the

quantity and especially in the quality of research evaluation and curriculum materials available. Legal implications involving the use of the computer are not posing any special problem and will not in the future if the Federal government continues favorable legislative practices in this area. There is a trend for costs to go down and capabilities of the equipment to go up. Based on the lower costs and better equipment trend, CAI will become more readily available to an increasing number of schools and research centers.

CAI in Des Moines. The information gathered also provided a foundation for formulation of conclusions regarding the requirements of CAI in Des Moines. These will be listed as responses to the questions to be answered of this report:

1. What elementary math materials are currently available which could be purchased and adapted for use in a CAI system in Des Moines?

   Packages are available from Science Research Associates and from Random House.

2. What materials would need to be produced locally to implement a program?

   A compiler would need to be developed including the necessary programming to incorporate it into the system.

3. What are the legal aspects of the computer utility and programs which would affect a system in the Des Moines area?

   There are none at the present time.

4. What would be the cost of establishing an elementary math CAI in Des Moines?

   Curriculum materials, related programming, and additional components may be leased at a starting price of approximately $18,778.

5. What aspects of the Des Moines area computer facilities are adequate for implementing CAI?

   The basic data processing configuration could possibly accept CAI lessons with special additions in programming and equipment. Speaking in terms of computer efficiency, costs, and the time element, neither of the Des Moines centers is adequate.

6. What additional equipment and/or technical aspects would be necessary?

   This would include a compiler, terminals, a control unit, a paper tape reader, a paper tape punch, data set, cables and supplies.

The problems that arise from an attempt to adapt commercially prepared programs to the existing equipment are so monumental that the only possible final conclusion is that CAI mathematics

packages are not technically or economically adaptable to the present Des Moines centers. A second conclusion is that a small CAI math project in Des Moines is still possible. Small computers, which are strictly one-building computers and can be used for the CAI program only, can be purchased at comparatively low prices. These computers are available at approximately $135 per student the first year of operation and at about $18 per student in subsequent years.

II. RECOMMENDATIONS

The review of the literature, letters of inquiry and the interviews provided a foundation for the major findings in this field report. Based on these findings, the two final conclusions, and the idea that interest in CAI will flourish in the Des Moines area, the author feels that the following suggestions or recommendations are in order:

1. A more concentrated investigation, including a complete feasibility study of CAI and its possibilities, problems, and evaluations should be undertaken.
2. The area centers should definitely take steps toward initiating a small CAI project.
3. If the decision is made to implement a small CAI project in the elementary school grades, an area which is reasonable for a system because of much research done, is the drill and practice mathematics program.

4. To implement such a system it is advisable to use commercially prepared curriculum materials.
5. It is inadvisable to attempt to adapt these commercially prepared materials to the existing equipment because of technical and economic problems.
6. Because of high start-up costs, it is advisable to begin with the purchase of a small eight-terminal computer that is used for the CAI math program only and is available at comparatively low costs.

On the basis of the above suggestions a final recommendation follows: a small eight terminal computer, including prepackaged mathematics materials, should be purchased in implementing a small computer-based instructional system in Des Moines.

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